The Role of Adaptive AI in Skill Development: A Comprehensive Survey

Sowmyashree S[1]; Manas Shet N[2]; Prashanth D M[3]; Pramanth P A[4]; Raghunandana M S[5]
Department of Information Science RNS Institute of Technology, Bengaluru

Abstract:- **E-learning systems facilitate accessible, flexible learning but often lack adaptive features tailored to individual student needs, leading to reduced effectiveness. Adaptive Intelligent Tutoring Systems (AITS) and Adaptive Hypermedia (AH) offer personalized support by monitoring student progress and adapting content and instruction. However, AITS excels in customized guidance, while AH generally provides technical resources without the same level of adaptation. The AI-Tutor system proposes integrating AITS and AH into an Adaptive Intelligent Tutoring System (AITS) to create a more effective e-learning environment. This combined approach promotes personalized knowledge sharing and enhances students' learning outcomes through adaptive, interactive content.**

Keywords:- *E-learning Platform, Adaptive Intelligent Tutoring Systems (AITS), Adaptive Hypermedia (AH), Personalized Instruction, Adaptive Learning, and Knowledge Sharing.*

I. INTRODUCTION

E-learning enables flexible learning, fostering motivation, communication, and skill acquisition through accessible, internet-based technology. By removing physical distance, e- learning connects students and instructors virtually, facilitating knowledge transfer and personal development across education, business, and training contexts. AITS has benefits, which include cost-effectiveness, time savings, and measurable learning outcomes, making it a practical approach to education.

However, traditional e-learning often lacks the adaptability needed to cater to individual learning needs, which can reduce AITS effectiveness. Intelligent Tutoring Systems (AITS) and Adaptive Hypermedia (AH) have emerged as solutions, offering adaptive instruction and tailored content through real- time student performance monitoring. AITS provides personalized guidance, while AH delivers technical resources, making both technologies integral to improving e-learning experiences.

To address these limitations, The integration of Adaptive Intelligent Tutoring System (AITS) for e-learning. AITS enables content adaptation based on each student's needs, facilitating a more interactive and effective learning environment. This integration promotes dynamic, personalized learning, allowing students to interact with and apply new knowledge more meaningfully. supports constructivist learning principles and enhances educational outcomes.

II. LITERATURE SURVEY

The literature on adaptive and intelligent tutoring systems (AITS) in e-learning explores various approaches to personalize learning, improve engagement, and enhance educational outcomes. The studies on AITS, adaptive hypermedia, cognitive modeling, and AI-powered tutoring are:

➢ *Integration of AITS and Adaptive Hypermedia (AH):*
The integration of Intelligent Tutoring Systems (AITS) and Adaptive Hypermedia (AH) to create Adaptive Intelligent Tutoring Systems (AITS) aimed at enhancing e-learning. It critiques traditional e-learning approaches that lack adaptability, suggesting that AITS can personalize content based on learners' needs, improving engagement and learning outcomes by dynamically adjusting to each student's knowledge and learning style.

➢ *User-Centered Adaptation in Human-Computer Interaction (HCI):*
Benyon and Murray focus on adaptive systems in Human-Computer Interaction (HCI) that respond to user-specific cognitive and personality through AITS. Through user modeling, they propose that adaptive systems tailored to individual cognitive abilities can improve interface usability. Their findings underscore the need for user-centered adaptations, suggesting that future educational systems should account for cognitive diversity in interface design to support effective learning.

➢ *Paula J. Durlach, Alan M. Lesgold-2012:*
The Tutor System discusses the state of adaptive training technology, particularly in structured domains like algebra. It highlights the challenges of adapting these technologies for less-structured scenarios, such as simulations and serious games. Contributions within the volume cover topics such as student modeling and virtual agents, making it relevant for developers and researchers aiming to expand adaptive systems to diverse educational and professional settings.

➢ *Wenbin Gan, Yuan Sun – 2019:*
Gan and Sun introduce "AI-Tutor," an AI-powered adaptive tutoring system that provides personalized support by analyzing cognitive assessments to target each student's weak points. The system generates tailored questions and feedback, aiming to improve knowledge retention efficiently.

➢ *Dr. Adeel Baig, Dr. John D. Cressler, Dr. Marvin Minsky-2024:*

The system discusses the role of AI in Indonesia's digital transformation, focusing on AITS application across sectors such as education, healthcare, and agriculture. It identifies both opportunities and challenges, including regulatory, ethical, and infrastructure issues, emphasizing the importance of robust AI frameworks. Although not solely education-focused, the insights on AI's transformative impact provide context for implementing AI-driven adaptive learning in broader educational reforms.

➢ *Ambroise Baillifard, Maxime Gabella–2023:*

Baillifard and Gabella examine AI tutors in educational settings, emphasizing personalization and adaptive learning techniques like spaced repetition. In a study at UniDistance Suisse, an AI tutor modeled students' progress and implemented retrieval- based practices, resulting in higher academic performance. Their research validates the role of neural-network-driven AI tutors in improving learning outcomes by adapting to individual learning paces and needs, reinforcing the effectiveness of personalized e- learning strategies.

➢ *Rainer Winkler, Julian Roos - 2019:*

The research identifies key design principles for SPAs, including interactivity, scaffolding, humanness, engagement, transparency, accessibility, flexibility, response time, and supportiveness. The system focuses on group discussions and a quasi-field experiment to evaluate the effectiveness of their designed SPA, which shows significant improvement in learning outcomes.

➢ *Objectives*

The goal of this survey is to thoroughly examine and compare current machine learning methods used for AI Tutor Systems.

- **Tailor Educational Content to Individual Learning Needs**: Develop a system that customizes learning materials and instructional approaches based on each student's unique learning preferences, performance, and progress.
- **Enhance Engagement and Motivation**: Integrate interactive and adaptive features that encourage student participation and keep them motivated throughout their online learning experience.
- **Monitor and Adjust Student Progress in Real- Time**: Enable both instructors and the system to track students' progress in real-time, adapting the content and delivery to suit their evolving learning needs.
- **Incorporate Constructivist Learning Strategies**: Provide simulations and real-world challenges that promote active learning, allowing students to apply knowledge through hands-on problem- solving.
- **Facilitate Long-Term Knowledge Retention**: Design learning paths that adapt to students' needs, offering personalized feedback and ensuring that they can retain and effectively apply what they have learned.

- **Enhance Learning Accessibility and Flexibility**: Offer a flexible learning platform that students can access at their convenience, eliminating time and location constraints associated with traditional education.
- **Measure and Improve Learning Outcomes**: Implement analytics and tracking tools to assess the effectiveness of personalized learning strategies, continuously refining the system based on student performance and feedback.
- **Support Collaborative Learning Experiences**: Provide platforms for students to collaborate with peers and instructors, fostering a community-driven approach to knowledge sharing and problem-solving.

➢ *Existing System*

Traditional e-learning platforms are web-based systems that provide access to course materials and resources but often rely on static content like lecture notes and videos. These systems typically lack interactivity and fail to adapt to individual learner preferences or progress. Adaptive Hypermedia (AH) offers some customization but focuses mainly on teaching concepts rather than problem-solving. Intelligent Tutoring Systems (AITS) excel in problem-solving but struggle to cover diverse knowledge areas. The lack of personalization and adaptability in current e-learning solutions highlights the need for more advanced, learner-centered approaches.

➢ *Proposed System*

The AI-Tutor System offers a deeply customized learning experience by integrating cognitive assessments and custom question generation to suit each student's needs. By combining adaptive course content with an automated problem-solving feature, the system provides targeted support that aligns with individual learning gaps. Through advanced machine learning and natural language processing, AI-Tutor evaluates students' knowledge levels and creates personalized questions that address specific areas for improvement, boosting retention and engagement. The system framework includes adaptive materials, tailored learning paths, and a data-driven problem solver that guides students with step-by-step feedback. This setup fosters a dynamic, interactive learning environment that adapts in real time to each learner's progress, supporting continuous improvement through ongoing analytics.

➢ *Advantages of Proposed System*

- **Customized Learning:** The system creates individualized learning paths and resources, using cognitive assessments to pinpoint and address each student's specific needs, improving overall learning effectiveness.
- **Instant Feedback and Flexibility:** The system actively tracks student progress, allowing it to give immediate feedback and adjust content dynamically, enhancing the learning experience in real time.
- **Focused Remediation:** AI-Tutor offers personalized question sets and detailed problem- solving guidance, helping students strengthen their understanding of topics efficiently compared to traditional approaches.

- **Enhanced Problem-Solving Skills:** With an AI-powered solver, students receive step-by-step hints for challenging problems, promoting independent thinking and a deeper grasp of concepts.
- **Adaptive Learning Paths:** Using data analytics, the AI-Tutor creates tailored course sequences and materials, making learning more engaging and aligned with each student's pace.

III. METHODOLOGY

➢ *The Methodology of the Proposed System Involves Several Stages:*

- **Collecting Learner Data:** The system first gathers essential details about each learner, such as their preferred learning style, current knowledge level, objectives, and interests. This information is used to develop a tailored learning path and choose the most suitable resources for them.
- **Creating a Personalized Learning Path:** Using diagnostic models, the system evaluates the learner's understanding of the subject and identifies areas that need improvement. Based on this evaluation, it crafts a customized learning path with specific content to meet the learner's needs.
- **Tracking Progress in Real Time:** As the learner moves through the material, the system logs data on completed courses, types of exercises attempted, and test results. This continuous tracking helps the system adapt content to the learner's progress and performance.
- **Generating Customized Questions:** After the learner completes a topic, the system creates specific questions to address areas where they may need more practice, ensuring targeted reinforcement of weaker points.
- **Providing Step-by-Step Problem Solving and Support:** The system includes an AI-driven problem solver that offers hints and detailed solutions as learners work on questions. This support promotes independent learning by guiding them through complex problems with structured assistance.

IV. SYSTEM ARCHITECTURE

➢ *Content and Knowledge Outside the System:*

Originally, Intelligent Tutoring Systems (AITS) relied on external learning resources, like lectures or textbooks, for foundational knowledge. However, as digital capabilities grew, combining AITS with online learning materials in one integrated system became more effective.

➢ *Combination of AITS and Adaptive Hypermedia (AH):*

Researchers began merging AITS with Adaptive Hypermedia (AH), as AH organizes online learning materials into accessible hypertext. This combination led to the development of Adaptive Intelligent Tutoring Systems (AITS), which leverages AITS and AH to deliver adaptive, personalized learning.

➢ *Expert Model with Adaptive Presentation and Navigation:*

The expert model within AITS includes Adaptive Presentation and Adaptive Navigation Support, allowing it to be applicable across various domains. This design enables the modification of lecture content, decision rules, and the evaluation criteria within the expert model, allowing AITS to adapt to diverse learning contexts.

➢ *Content Personalization Based on Learner Knowledge:*

The expert model uses stored information about the learner's knowledge to recommend relevant content. It assesses what a learner already knows and what they need to learn next, using prerequisite relationships between topics to suggest suitable lectures. The learner can either be shown a recommended lecture or given a choice based on their learning style.

➢ *Dynamic Selection of Learning Material:*

By blending AH and AITS, AITS can adaptively select the most suitable learning material from AITS knowledge base, presenting it at the ideal time and in the right format for each learner. This method ensures that all educational resources are used efficiently, providing targeted support for concept mastery and practical application.

➢ *Integrated Instructional Approaches for Comprehensive Learning:*

Since AH is ideal for conveying conceptual knowledge and AITS excels in problem-solving support, combining both approaches offers a comprehensive learning experience. Together, they allow AITS to adapt content dynamically according to each learner's behavior, preferences, and progress online.
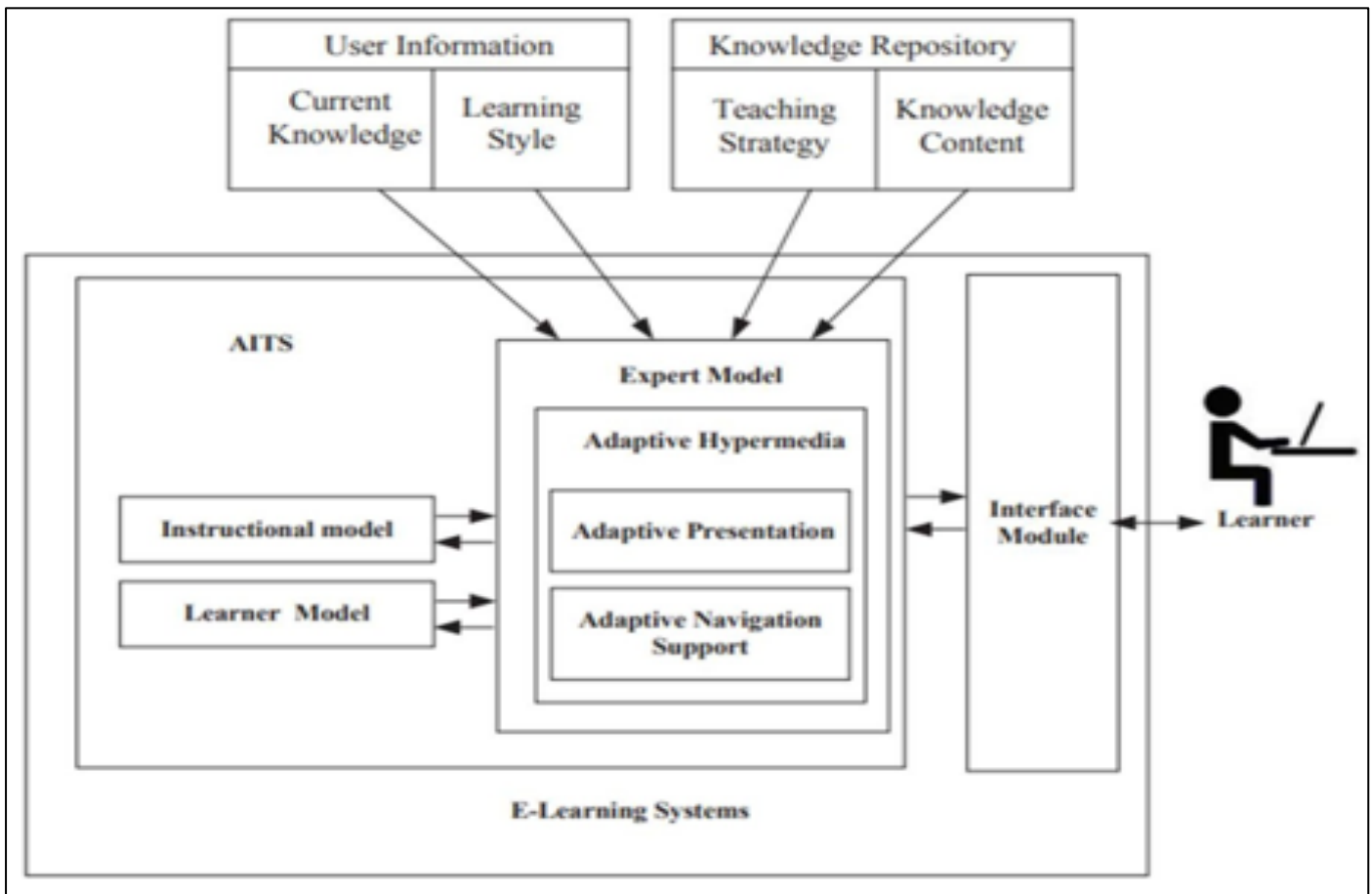
Fig 1 Conceptual of Adaptive Intelligent TutoringSystems for E-Learning System

V. CONCLUSION

Adaptive Intelligent Tutoring Systems (AITS) is the valuable tools for computer-based learning. Current efforts focus on merging these systems to enhance e-learning by providing personalized instruction that adapts to each student's learning style. AITS acts as an integrated model, allowing both systems to share data on a learner's progress. This approach aims to strengthen the connection between teaching concepts and skill application, ultimately improving learning outcomes.

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